tion errors typically happen either due to erroneous channel information, changed channel conditions, or just aggressive link adaptation, where the scheduling unit pushes a modulation and coding scheme used to a limit to get the maximum throughput possible.

[0020] In existing versions of modern wireless communication standards such as LTE and HSPA, there is a strong dependence on dynamically scheduled transmissions of user plane data. This means that a base station (called eNB in 3GPP LTE) first sends a downlink control information (DCI) message to a user equipment (UE). This DCI includes a resource allocation message (information on physical resources used, modulation and coding scheme, HARQ information—a process ID and whether new data is present or not, etc.) for a downlink direction, and an uplink grant for a case where UE is expected to perform uplink transmissions. Here the uplink grant contains information on the physical resources to be used, the modulation and coding scheme, HARQ related information, and a specific sequence of reference symbols to be used for demodulation of data). Each regular scheduling decision for both uplink and downlink are controlled by eNB. To enable the most efficient operation, there is a very strict timing relationship regarding when particular things are supposed to happen within the system. There is typically a fixed relation between the scheduling grant, transmission of data, transmission of HARQ feedback, and the earliest possible retransmission time. These fixed timing relations have been introduced to have near-optimum operation of the system. Using the fixed timing relations provide a possibility to fill a pipeline with data such that each UE may potentially have continuous data transmission/reception, but also to allow for efficient and implicit resource allocation for feedback channels (such as PUCCH based uplink channels and PH ICH downlink channels).

[0021] Using a fixed and predefined timing structure for the communication system is setting some processing time requirements on a node that is receiving the data.

[0022] Air interface latency (i.e. HARQ timing) also has a considerable cost impact. For example, it defines the size of a HARQ buffer. The more relaxed latency, the more data buffering is needed (reduced HARQ timing may lead to an increased cost due to the data buffering). Furthermore, over-dimensioned processing times also increase the length of a data call at least in some MTC scenarios, and this has a negative impact on UE power consumption. On the other hand, in the case of the highest data rates/highest load, a baseband processing capability of UE and/or eNB may be a limiting factor in reducing the latency. In these cases there might be no room for reducing the air interface latency. For the sake of varying requirements, the fixed HARQ timing approach is not appropriate for the coming communication systems.

[0023] Regarding the HARQ operation in LTE (downlink HARQ operation and uplink HARQ operation), the existing systems have been considering the fixed timing relations for transmission, feedback, and potentially a new retransmission.

[0024] FIG. **1** illustrates the timing relationship in synchronous LTE UL (FDD mode) where stop-and-wait HARQ is applied with 8 parallel HARQ processes.

[0025] In terms of processing power capabilities, the 3GPP systems have allowed for some differentiation, as there are some UE capabilities that have fewer HARQ buffers, but the timing requirements for these capability classes are still fixed and defined from standards.

[0026] The concept of dynamic frequency scaling is related to “throttling” a processor speed to adjust the processing power to the current need.

[0027] Further, from a power consumption point of view, it is better to calculate slowly and be ready just in time compared to calculating fast and wait for applying the result.

[0028] On the other hand, to minimize the “on-time” of a modem part of a transceiver it is typically most power efficient to convey the data as fast as possible.

[0029] An exemplary embodiment enables introducing variable HARQ feedback timing and operation in wireless systems.

[0030] In an exemplary embodiment, different mobile units (i.e. user equipment UE) may have different processing time requirements depending e.g. on the conditions that UEs experience.

[0031] In an exemplary embodiment, a concept of flexible HARQ timing is introduce within the wireless systems. There are a number of ways that this principle may be implemented. An exemplary principle is to allow for flexibility in the HARQ timing such that UE or eNB may have more (or less) time to do the actual processing of the data in both ends of the communication link. For example, a time interval between UE receiving the downlink transmission and UE being expected to provide the related uplink control information (ack/nack in the uplink) may be configurable (or defined during initial access to a cell). Correspondingly, the time that eNB has to process the uplink control information until UE at earliest expects retransmission may be configurable. The same principles may be applied for the uplink scheduling (here with configurable delays between scheduling grant, uplink transmission, downlink retransmission indication, and the potential retransmission).

[0032] In an exemplary embodiment, different (configuration) options with different HARQ timing profiles are made available for communication involving (at least) two nodes, wherein each HARQ-timing profile has pre-defined processing times defined for data and control processing at both ends of the communication link. These options may be used e.g. such that one device category (e.g. MTC/low data rate devices) applies one HARQ timing profile whereas another device type (e.g. data centric UE) applies another HARQ timing profile. The applied HARQ timing profile may also depend on a cell and/or service type. The different HARQ timing profiles may or may not involve a different number of HARQ processes.

[0033] In an exemplary embodiment, multiple HARQ-timing profiles coexist in a common resource space containing frequency and time resources.

[0034] An exemplary approach of operating HARQ may introduce significant changes to the way that a HARQ control loop is typically considered. On the other hand, it allows for the different UEs to operate in different ways. In an extreme case, some very low power UEs (such as MTC devices) that may be running at an extremely low power consumption and may have limited processing cycles available per second, may be operating in the same system as high processing power capable devices with ultra-fast responses. In that case eNB or an access point may have more book-keeping to make sure that there are no collisions on the control channels (data channels may be multiplexed e.g. based on frequency domain multiplexing).